METHOD FOR RECYCLING BUILDING MATERIALS

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Cross-Reference to Related Applications

This application is a continuation of co-pending application, U.S. Serial Number 10/226,051 filed August 22, 2002 which is a continuation-in-part of U.S. Patent Application Serial No. 09/715,745, filed November 17, 2000, now U.S. Patent No. 6,439,139 all of which are incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention is related generally to a method and apparatus for recycling building materials in as a supplemental fuel source and source of raw material(s).

Prior Art

Cement is produced by heating raw materials, forming a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other ingredients. Common among the materials used in its manufacture are inorganic materials, such as limestone, shells, and chalk or marl combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore. Lime and silica typically make up about 85% of the mass. The raw materials are heated in a cement kiln at high temperatures of typically 2600°F to 3000°F (1430°C to 1650°C). The inorganic minerals are "digested" in the kiln through a very complex set of chemical reactions, yielding oxides, and then finally complex silicates, which comprise the clinker. At 2700°F (1480°C), this series of chemical reactions cause the materials to fuse and create cement clinker-grayish-black pellets, often the size of marbles. Clinker is discharged red-hot from the lower end of the kiln in marble-sized pieces, and is transferred to various types of coolers to lower the clinker to handling temperatures. Cooled clinker is combined with gypsum and ground into a fine gray powder. The clinker is ground

so fine that nearly all of it passes through a No. 200 mesh (75 micron) sieve. This fine gray powder is (termed) Portland cement.

The raw materials are placed in the high end and as the kiln rotates the materials move slowly toward the lower end. Natural Gas through Flame jets, and/or pulverized coal is feed in the lower end of the kiln to heat the materials in the kiln. Utilizing counter current flow, the kiln heat drives off, or calcines, the chemically combined water and carbon dioxide from the raw materials and forms new compounds (tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium aluminoferrite). Of the material that goes into the feed end of the kiln, about 67% is discharged as clinker.

As described in U.S. Patent 5,454,333, pumpable and solid hazardous wastes have been used a supplemental fuel to produce the heat for heating the mixture. Such wastes are typically used primarily for the heat value thereof.

U.S. Patent 5,888,256, which is incorporated herein by reference, describes a process for using various waste fuel sources, analyzing the ash of each, and adjusting the raw material inputs for the cement based on the ash composition. Such wastes are previously known wastes used in such processes, such as sludge waste and such.

U.S. Patent 5,888,256, which is incorporated herein by reference, describes a process for using various waste fuel sources, analyzing the ash of each, and adjusting the raw material inputs for the cement based on the ash composition. Such wastes are previously known wastes used in such processes, such as industrial waste sludge. The '256 patent requires a minimum of two waste streams, and blending and grinding to achieve a maximum 1000-micron particle size with a minimum BTU value and a maximum ash content. Accordingly, the '256 patent restricts the type and form of wastes which can be used.

U.S. Patent 5,833,474 describes using waste materials from electric arc furnaces to supplement the input materials for cement to provide an inexpensive raw material, but not to recover fuel value therefrom.

Likewise, during combustion of organic materials, undesirable emissions typically occur, including SO_x and NO_x. The level of such emissions may be affected by controlling the combustion temperature and adding calcium carbonate during combustion. A preferred means of accomplishing this includes the use of a fluidized bed boiler ("FBB"). In such a boiler, a bed is fluidized. This bed consists of fuel and lime added to the bed. NO_x is

generally lower in a FBB due to the relatively low temperature of the bed. As an added NO_x control, secondary air can be used as overfire air to further control NO_x. The lime within the bed captures the SO_2 released from the burning fuel and reacts to form calcium sulfate (gypsum).

Asphalt shingles have been used extensively as a roofing material for the construction of buildings. In the process of making shingles, an organic or glass mat is coated with asphalt filled with limestone or dolomite, and inorganic granules are imbedded in the filled asphalt. Waste product from such an operation, or shingles removed from a house after their useful life, are sent to a landfill, due to the variety of materials used and the difficulty in separation of such materials. Often during the removal of old shingles form a house, nails used in the installation thereof, as well as rotten boards, tar paper, vents and other such materials are removed and sent with the shingles to the landfill. Furthermore, composite shingles have come into use in the recent past, an example of which is the Owens Corning Mira Vista ® Shake, which comprises a filled polymeric shingle. Similar to the asphalt shingle, such a composite shingle may be recycled by combusting the polymeric material and using any filler materials therefrom as a component of the cement. Furthermore, other building materials such as siding materials, including asphalt siding, cedar siding, cementious siding and such, may be recycled in a similar manner.

It would be desirable to find an alternative disposal method for scrap building materials from the manufacturing process and building renovations, including asphalt shingles.

BRIEF SUMMARY OF THE INVENTION

According to the present invention, an improved recycling process is described to recycle building materials. As such, the disposal costs and landfill space for such materials are avoided. Furthermore, the energy value of such materials is recovered, and the inorganic constituents of the shingles or recycled building materials are incorporated and become part of the minerals useful in the manufacture of cement, and/or used as a material for reducing the emission of undesirable emissions, reducing the cost for these inputs in the manufacture of cement, or in the combustion process of a fluidized bed boiler.

Accordingly, a method of recycling building materials is described, including the steps of introducing the building material into a cement kiln or fluidized bed, and combusting a combustible portion of the building material as a fuel within the kiln or bed. The noncombustible portion of the building material is incorporated into a clinker material within the kiln, or utilized as a bed material and/or to reduce the sulfur emissions from combustion.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic side view of a cement production facility using the present invention.

Figure 2 is a schematic side view of a fluidized bed boiler using the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Cement is produced by preparing the necessary raw materials in the necessary proportions and in the proper physical state of fineness and intimate contact so that chemical reactions can take place at the calcining and sintering temperatures in the kiln to form the end product, typically referred to as clinker. In general, the raw materials are crushed, passed through grinding, separation and mixing apparatuses and then introduced to a kiln.

As noted in the Background section, to reduce energy and raw material expense(s), numerous methods have been suggested to introduce waste materials in the kiln during the manufacture of Portland cement. U.S. Pat. No. 3,572,524 describes an apparatus for charging sludges and other similar waste materials to the feed end of a rotary incinerating kiln using an endless screw-conveyor. U.S. Pat. No. 4,850,290 to Benoit et al., describes a method for charging drums of solid hazardous waste directly into the central portion of a rotary kiln or into the feed end housing of a kiln. U.S. Patent 5,454,333,describes a continuous feed method for various waste materials, such as tires or drums of hazardous waste, and describes various other methods for introducing solid hazardous waste fuels into the rotary kilns. These patents are incorporated herein by reference for such teachings.

Figure 1 gives a schematic overall diagram of a cement production apparatus 10. A kiln 20 includes an input end 12. Raw materials 14 are input into the input end 12 in a known manner. As taught in the prior art references, such input materials may enter into a

precalciner kiln system prior to introduction into the kiln 20. The kiln 20 may optionally include a supplemental fuel introduction system 16, as described in the '256 patent. If so equipped, fuel 18 is introduced as described therein. As noted above, after the materials are calcinated, clinker is dispensed from the exit end 22 of the kiln and handled in a known manner. The material input system used with the present invention may include a number of systems as described in the prior art and are therefore not described herein in detail.

Scrap shingles, either the byproduct of the manufacturing process for roofing shingles, or shingles which are removed from an existing house, may be used as a fuel and raw material for the production of Portland cement. Such shingles include asphalt coating, which is useful as a fuel within the kiln. The asphalt coating includes filler materials, such as limestone, which is an input material for cement. The shingles further include a mat, made from either organic material, which is further useful as fuel, or a glass fiber mat. The glass fiber mat, when separated from the asphalt and granules within the kiln, provides a source of silica, which is another input material for the cement. The silica is then combined with the other cement inputs within the kiln, and is formed into the clinker. Normally, shingles include granules, which provide further crushed and screened minerals, which provide additional inputs for the concrete. Fiberglass asphalt shingles typically comprise about 20% asphalt, 2% glass fiber, 65% limestone, and the balance comprises various materials, mostly minerals.

When a roof is stripped of shingles, additional building materials, such as roofing underpayment (frequently asphalt coated glass or organic mat), rubberized sheeting (ice guard), nails, wood from the roof deck, roof vents, and other materials are also removed and discarded with the shingles. The nails provide iron, another input to the cement; while the felt may provide fuel and glass; while the wood provides additional fuel for the kiln. As such, scrap shingles provide several inputs to the cement manufacturing process, as both fuel and raw materials, unlike other previously proposed waste materials. As such, preferably the mixture of inputs to the cement manufacturing process is determined and modified in a manner as described in the '256 patent to create the desired clinker formulation.

Preferably, the building materials, including the shingles, may be introduced without grinding into the raw material hopper (12), and the rotating kiln. Within the kiln, combustion of the organics destroys the structure of the shingles and other building materials, and the

remaining inorganic materials are fully incorporated into the clinker within the kiln. However, depending on the feed system, it may be desirable to mill or grind large input materials in some instances.

In a similar manner, natural shingles, such as cedar shakes, may be disposed as a fuel source in a cement kiln. Furthermore, composite shingles have come into use in the recent past, an example of which is the Owens Corning Mira Vista ® Shake, which comprises a filled polymeric shingle. Similar to the asphalt shingle, such a composite shingle may be recycled by combusting the polymeric material and using any filler materials therefrom as a component of the cement.

Furthermore, other building materials may be recycled in a similar manner, using the fuel value of the materials in the cement kiln, while using the noncombustible components as additional raw materials for the cement. Examples include siding materials, such as vinyl siding, asphalt siding, cedar siding, cementious siding and such, may be recycled in a similar manner. Likewise, fiberglass insulation may be recycled by placing such within the kiln, and although mostly noncombustible, provides silica and other inorganic constituents for the cement.

Figure 2 schematically illustrates a fluidized bed boiler 210. Such a boiler may comprise a bubbling bed, circulating fluidized bed, or any known fluidized bed. In such a boiler, fuel is fed from a feed source 212, and limestone is fed from a second source 214 into the bed 216 as an emissions reduction material. In such fluidized bed combustion, fuel is introduced into the fluidized bed 216 and combusted. The fluidization is achieved by blowing relatively low-velocity air into a medium such as sand. Lime is injected into the bed 214. The present invention may be used in a variety of fluidized beds, and therefore they are not described herein in great detail. An exemplary description of a fluidized bed boiler and its operation is included in <u>Design Considerations of B&W Internal Circulation CFB Boilers</u> by Kavidass and Alexander, presented to Power-Gen Americas '95, Dec 5-7, 1995, which is incorporated herein by reference. In the instant invention, the building materials are fed into the fluidized bed, and the organic portion of the building materials is combusted.

Typically a CFB utilizes fuels having between 3500 and 7000 British Thermal Units per pound (BTU/lb), and inject limestone in an amount of about 20% by weight of the fuel. When asphalt shingles are so combusted in a CFB, the fuel value comprises about 4200

British Thermal Units per pound (BTU/lb) (primarily from the asphalt coating), and contain about 30-40 percent limestone (calcium carbonate primarily from the asphalt coating filler), as well as other inorganic materials such as the glass mat and colored granules. In such an application, the shingles would preferably comprise a portion of the fuel and a second fuel, preferably with higher BTU value and lower lime percentage, is used to optimize combustion and emissions. When asphalt shingles are combusted, the asphalt from the shingles is combusted, the limestone is used within the bed to control gases such as SOx and NOx, and the granules and such are added to the bed as particulate bed material. During operation of the bed while feeding these or other such building materials, the amount of limestone and bed material is adjusted based on the amount of each contained in the building materials, as described above with respect to asphalt shingles. Additionally, in a roof tear-off situation, wood and tar paper and/or other building materials will contribute additional energy value as well as inorganic bed materials, as is the case where other building materials, such as siding, are combusted.

Preferably when building materials such as shingles are combusted, a grinder, such as a Packer 2000 manufactured by Packer Industries of Mableton, GA, is used to reduce the size of the shingles to pieces of preferably less than 3 inches in any dimension. Preferably, the ground shingles are then fed into a hammer mill with other combustion materials to reduce the size to less than ½ inch in any dimension. In one trial at the Colmac Resources, Inc. Piney Creek power plant in Clarion, PA, scrap shingles and manufacturing waste from Owens Corning's Medina, OH shingle plant were ground and fed into a of waste coal at a ratio of about 10% shingle scrap to total fuel. The ground shingles and waste coal were hammered and fed into a CFB, and the flow rate of the feed limestone dropped over 3% (from the typical 20%) to below 17% by weight of fuel due to the lime content of the shingles. Accordingly, in this example, the shingles provided 15% of the total lime required to maintain the emissions, and the mixed fuel burned acceptably and emissions were within permissible limits. One skilled in the art appreciates that the lime feed system may be adjusted based on the amount and type of filler in the shingles (or other building material) in combination with the percentage of shingles to other fuels fed into the boiler, as well as the amount of sulfur in the fuels, acceptable emissions limits, and other control mechanisms on the boiler. Similarly, when other building materials are combined with the fuel stream, the

fuel value, lime content, and filler content may used to adjust the stream of fuel, lime and bed materials into the fluidized bed to an appropriate ratio.

As noted above, fluidized bed combustion primarily consists of the bubbling type and the circulating type. In the bubbling type, because the velocity of the air is low, the medium particles are not carried above the bed. In the circulating type, the velocity of air is high, so the medium particles are carried out of the combustor. The carried particles are captured by a cyclone installed in the outlet of combustor.

In the bubbling type, combustion is generated within the bed. In the circulating type, combustion is generated in the whole combustor with intensive movement of particles. Typically secondary air is added above the bed to minimize the excess air during primary combustion so as to minimize the generation of pollutants. In such a CFB, particles which leave the bed are continuously captured by the cyclone and sent back to the bottom part of the combustor to combust unburned particles and maintain the bed.

As described above, the input materials are fed into the bed, the combustible portion, such as asphalt from roofing shingles, is combusted, and the noncombustible portion remains. In the present invention, the filler (lime) from the shingles is then used within the bed as an input material to react with the sulfur and reduce emissions. The remaining inorganic materials may become part of the bed as well.

The embodiments were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. Also such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally and equitably entitled